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TUBERCULOSIS OF CATTLE.[a]

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[Revised in 1904 by Doctors Salmon and Mohler.]

Tuberculosis is an infectious and communicable disease characterized by the formation in various organs of the body of minute nodules, or tubercles, which contain the *Bacillus tuberculosis*, the cause of the disease.

The disease, in its various manifestations, has been known for many centuries, and legislative enactments having reference to the destruction of affected animals and forbidding the use of the flesh date far back into the middle ages. The opinions entertained regarding the nature and the cause of the malady varied much in different periods, and very markedly influenced the laws and regulations in vogue. Thus, in the sixteenth century, the disease was considered identical with syphilis in man. In consequence of this belief very stringent laws were enacted, which made the destruction of tuberculous cattle compulsory. In the eighteenth century this erroneous conception of the nature of the disease was abandoned and all restrictions against the use of meat were removed. Since that time, however, the communicable nature of this disease has been established by many investigators, and the tide of opinion has again turned in favor of repressing the disease and prohibiting the sale of contaminated products.

Occurrence.—The statistics concerning tuberculosis show that it is a disease prevalent in all civilized countries. In some countries, such as the northern part of Norway and Sweden, on the steppes of eastern Europe and Russia, in Sicily and Iceland, and in Algiers, it is said to be quite rare.

The returns from testing British cattle with tuberculin, supplied by the Royal Veterinary College, as stated in March, 1900, showed that among 15,392 animals tested 4,105, or 26 per cent, reacted.

During the slaughter of cattle for pleuro-pneumonia careful examinations of the carcasses were made for tuberculosis. Of 300 head killed near Edinburgh 120, or 40 per cent, were tuberculous. Of

[a] Reprint from Special Report on Diseases of Cattle. 1904.

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4,160 killed in England 20 per cent were tuberculous. Of one of these lots of cattle (451 animals), the president of the Lancashire Farmers' Association testified that they were fairly representative cattle—cows, heifers, and growing stock—a thoroughly mixed lot; 20 per cent of these animals had tuberculosis.

Of 398 bovine animals taken haphazard in the city of Manchester, 120, or 30 per cent, were tuberculous. Among these animals were 168 cows, 69, or 41 per cent, being tuberculous, and 2 having diseased udders.

The result of testing the Queen's herd at Windsor was that 36 out of 40, or 90 per cent, were found tuberculous.

The investigations made by the British Dairy Farmers' Association deserve particular attention, coming as they do directly from a cattle owners' organization. The council of this association "resolved to submit the general consideration of the question to a committee, with a view to some more definite understanding as to the possible extent to which tuberculosis exists in dairy cattle." The secretary was instructed to write to a number of dairy farmers, being members of the association, asking their cooperation and the use of their herds for the application of the tests. Of the herds offered, 9 were selected, containing 461 cows and 12 bulls, and 188 of these animals reacted, being 40.8 per cent. There were among these cattle 335 Shorthorns, of which 119, or 35 per cent, reacted; 67 crossbreds, of which 28, or 42 per cent, reacted; 47 Aryshires, of which 37, or 80 per cent, reacted.

Another experiment of much interest is that of the Cheshire County council. The technical instruction committee set aside £250 to be used by a joint committee from the agricultural and horticultural schools and Worleson Dairy Institute for applying the tuberculin test to their herds. The tests were made February 15, 1899. The results were: Worleson herd of 54 animals, 16 diseased, or 29.6 per cent; agricultural school herd of 17 animals, 4 diseased, or 23.5 per cent. The Worleson herd consisted of Shorthorn cows. In each herd the purebred Shorthorn bull was tuberculous. The results of the tuberculin test were confirmed by the slaughter of the animals and examination of the carcasses.

Sir T. D. G. Carmichael, member of Parliament for Midlothian, gave evidence before the royal commission that his Polled Angus herd was tested in the spring of 1895. "The results of the test were fearfully unexpected and alarming." Of 30 tested 13 showed decided reaction—43 per cent. Again he speaks of having 41 animals tested the same spring and 16 reacted—39.5 per cent.

Of 80 Shorthorn cattle, intended for export, which were tested, 34 reacted, or 42 per cent.

Of a herd of 25 British Shorthorns recently tested in quarantine, 40 per cent were found tuberculous.

The addition of these animals above referred to gives 20,930 head examined and 5,441, or 26 per cent, pronounced tuberculous. And these herds were not selected because they were supposed to be tuberculous, but represent the general cattle stock of the country. These animals included at least 470 head of Shorthorns, of which 170, or 34 per cent, were tuberculous.

To these facts may be added the evidence of Professor Bang that tuberculosis was brought to Denmark in the first half of the nineteenth century by cattle from Switzerland, Schleswig, and England, and that the same thing is now going on in Sweden and Norway, particularly through English cattle. Also the evidence of M. Sivori, chief of section at the ministry of agriculture, Argentina, who has investigated tuberculosis in that country, and who says that "thirty or forty years ago tuberculosis was unknown in Argentine cattle, and it is still unknown among the native (criollo) cattle. Its appearance dates from the introduction of pure breeding animals. Statistics prove that tuberculosis is observed among the grades—above all among those of the Durham and less among the Hereford."

Moreover, the reports of the royal commission of Victoria, Australia, and of the New Zealand department of agriculture, show a large proportion of tuberculous cattle in those colonies, where the disease was almost certainly carried by British cattle.

In the same manner that tuberculosis has been carried from Great Britain to Denmark, Sweden, Norway, Argentina, and Australia, it has also been taken to Canada. In one herd of imported cattle slaughtered in the Canadian quarantine station, 13 of the 14 animals were found tuberculous. One of the largest Shorthorn herds in Canada was some time ago tested because an animal from it was condemned when offered for shipment to the United States. This herd was found to be very badly affected, and an effort is being made to eradicate the disease by the Bang method. A Canadian official publication says of another Shorthorn herd, which at one time had a very high reputation, that when an investigation in regard to tuberculosis was recently made the disease was found among ordinary cattle wherever animals from this herd had been introduced; and that this herd, which had been looked upon as one of the greatest benefits to the farming community, was really a danger, because it disseminated tuberculosis among the farmers' herds. Still another well-known herd recently attracted attention because four animals from it offered for export to the United States were all tuberculous.

From December 23, 1900, to February 19, 1901, the period that the Department inspector tested all Canadian cattle intended for shipment to the United States, 140 purebred Shorthorns and 3 Shorthorn grades were tested, and of the total number 26, or 18 per cent, reacted. During the first month that this inspection was enforced,

and when it may be assumed that the condition of the cattle most nearly represented what it had previously been, 74 cattle were offered for importation, and 18, or 24.3 per cent, were found tuberculous.

In justice to Shorthorn cattle it should be said in this connection that they are probably no more susceptible to tuberculosis than are other breeds, but the disease has been allowed to spread in certain herds and families to such an extent as to give a wrong impression concerning the breed as a whole.

The slaughterhouse statistics of Prussia show 14.6 per cent of the cattle and 2.14 per cent of the hogs to be tuberculous. In Saxony the percentage is 29.13 with cattle and 3.10 with hogs. In the city of Leipzig the figures are 36.4 for cattle and 2.17 for hogs. (Siedamgrotzky.) Of 20,850 animals in Belgium tested with tuberculin in 1896, 48.88 per cent reacted. (Stubbe.) Of 25,439 tested in Denmark from 1893 to 1895, 49.3 per cent reacted; and of 67,263 tested from 1896 to 1898, 32.8 per cent reacted. (Bang.)

Figures available in the United States do not cover a sufficient area of our territory to allow us to make a reliable estimate of the extent of tuberculosis with milch cows. There is little doubt, however, but that the disease has been increasing both with dairy cattle and hogs. From a recent review by Russell and Hastings, of the Wisconsin Agricultural Experiment Station, of tests of cattle for tuberculosis which have been made in the United States, the following summary is presented:

Statistics of tests for tuberculosis in the United States.

State.	Number tested.	Number tubercular.	Per cent tubercular.
Vermont	60,000	2,390	3.9
Massachusetts	24,685	12,443	50.0
Massachusetts, entire herds	4,093	1,080	26.4
Connecticut	6,300	.....	14.2
New York, 1894	947	66	6.9
New York, 1897-98	1,200	163	18.4
Pennsylvania	34,000	4,800	14.1
New Jersey	2,500	.....	21.4
Illinois, 1897-98	929	.....	12.0
Illinois, 1899	3,655	560	15.32
Michigan	.....	.....	13.0
Minnesota	3,430	.....	11.1
Iowa	873	122	13.8
Wisconsin:			
Experiment Station tests—			
Suspected herds	323	115	35.6
Nonsuspected herds	935	84	9.0
State veterinarian's tests—			
Suspected herds	588	191	32.5
Tests of local veterinarians under State veterinarian, cattle intended for shipment to States requiring tuberculin certificate	3,421	76	2.2

The State veterinarian of Pennsylvania, Doctor Pearson, thinks that not over 2 per cent of the cattle of that State are tuberculous, and probably if a general test of all the cattle of the other States mentioned were made we should find a very much smaller proportion tuberculous than is indicated by this tabular statement.

The beef cattle of the United States, as they come to the large packing houses, are yet comparatively free from tuberculosis. Of 4,841,166 cattle slaughtered in the year 1900 under Federal inspection, but 5,279, or 0.11 per cent, were sufficiently affected to cause the condemnation of any part of the carcass. Of 23,336,884 hogs similarly inspected, 5,440 were sufficiently affected to cause condemnation of some part of the carcass. This is equal to 0.023 per cent, or slightly more than one-fifth the proportion found in beef cattle.

In 1903 the number of cattle inspected reached 6,134,410, of which 8,848 carcasses or parts were condemned for tuberculosis, being 0.14 per cent. The number of inspected hogs was 21,793,738, and of these 72,305 carcasses or parts were condemned for this cause, or 0.33 per cent. The increase in percentage of condemnations from 1900 to 1903 was at least partly due to more stringent inspection.

It has been observed that tuberculosis increases in frequency with the age of the animals. If we take the number of cases of animals of a year and under affected with tuberculosis as the unit of comparison, animals from 1 to 3 years old furnish 10 times, those 3 to 6 years old 30 times, and those over 6 years 40 times the number of cases.

From the statistics above referred to and other data, it appears that in the more densely populated areas of Europe and America from 5 to 50 per cent of the dairy cattle are more or less affected with tuberculosis, while the proportion of beef cattle affected is distinctly less, ranging from 0.14 to 30 per cent. This difference is due to a number of causes. Beef cattle average younger when slaughtered. They are not so frequently stabled, and are for that reason less liable to infection, and, as the males constitute a large proportion of this class of animals, the effect of milk secretion in lowering the vital forces is not so apparent.

Cause and nature of the disease.—The cause of tuberculosis is the tubercle bacillus, which gains entrance to the body, lodges somewhere in the tissues, and begins to grow and multiply at that point. As this bacillus vegetates and increases in numbers it excretes substances which act as irritants and poisons, and which lead to the formation of a small nodule called a tubercle, at the point of irritation. As the bacilli are disseminated through the animal body they affect many points and cause the formation of an enormous number of tubercles. By the union of such tubercles masses of tubercular material are

formed, which in some cases are of great size. The disease is called tuberculosis because it is characterized by the formation of these peculiar nodules, and the bacillus which causes the disease is for the same reason known technically as the *Bacillus tuberculosis.*

There are undoubtedly predisposing conditions which contribute toward the development of the disease; some of these are found in the animal body and others in the environment. An enfeebled condition due to insufficient food, exposure to great extremes of atmospheric temperature and insanitary surroundings, or the drain occasioned by heavy production of milk, appears to aid the development of the bacillus, and there is also a special individual susceptibility in some cases which may be otherwise described as an inability of the animal tissues to resist and destroy the bacilli when they have penetrated to the inner recesses of the body.

Among the conditions of environment which aid the development of tuberculosis may be mentioned stabling with lack of ventilation, damp buildings, the keeping of many animals together, drafts of air which cause colds and catarrhs, and, in general, everything which prevents the animals from developing and maintaining the highest condition of health. None of these conditions of body or environment are sufficient to cause the disease, however, unless the animals are exposed to the *Bacillus tuberculosis* and this bacillus penetrates the tissues of their bodies.

The ways in which the tubercle bacilli find their way into the body, in the order of their importance, may be considered under four heads: (1) By inhalation into the lungs; (2)by taking into the digestive tract in the milk of tuberculous cows or with other contaminated food; (3) during coition when the sexual organs are tuberculous; (4) from the tuberculous mother to the fetus in the uterus. Inhalation appears to be by far the most common mode of infection. The bacilli can only reach the lungs by inhalation when they are thoroughly dried and pulverized and in a condition to be carried by currents of air.

It is well known that the bacilli withstand drying for months before they lose their power of producing disease. They leave the body of diseased animals in several ways. There may be a little discharge occasionally coughed up from the diseased lungs, or there may be ulcers of the intestines from which many bacilli escape and are carried off with the excrement, or milk may be spilt, or there may be a discharge from the vagina when the genital organs are tuberculous. The bacilli from these sources may become dried and pulverized and carried in the air of the stable and into the lungs of still healthy cattle, where the disease then develops.

The disease of the stomach, intestines, and mesenteric glands is very probably the result of food infection. Tubercle bacilli may have

been scattered upon the feed by diseased animals. But the most common source of such infection is the milk of tuberculous cows. Calves may become infected in this way. The disease may remain latent until the animal becomes older. The not infrequent occurrence of tuberculosis of the uterus and ovaries makes it probable that the disease may be transmitted by a diseased bull or carried by a healthy bull from a diseased cow to a number of healthy cows.

The source of infection is always some previous case of the disease, for the latter can never arise spontaneously. Hence, in those stables in which there is frequent change of cattle the introduction of tuberculosis by cattle coming from other infected stables is the most frequent source of infection. Since the bacilli when dried can be carried by the air, it is not necessary that healthy animals should come in direct contact with cases of disease to become infected. In general the greatest number of cases occurs in the immediate environment of cities, where there are not only abundant opportunities for infection, owing to the frequent introduction of new animals into herds, but where the sanitary conditions may be regarded as the poorest.

The bacillus of tuberculosis was discovered by Robert Koch in 1882. It is a slender, rod-like body, from one-third to two-thirds the diameter of a red-blood corpuscle in length. As already explained, when the bacillus has become lodged in any organ or tissue it begins to multiply, and thereby causes an irritation in the tissue around it, which leads to the formation of the so-called tubercle. The tubercle, when it has reached its full growth, is a little nodule about the size of a millet seed. It is composed of several kinds of tissue cells. Soon a change takes place within the tubercle. Disintegration begins, and a soft, cheesy substance is formed in the center, which may contain particles of lime salts. When these tubercles continue to form in large numbers they run together, forming masses of various sizes. The disintegration which attacks them leads to the formation of large cheesy masses of a yellowish color, containing more or less of lime salts in the form of gritty particles. These large, tuberculous masses are surrounded by or embedded in layers of fibrous tissue, which in some cases becomes very dense and thick.

The disease is thus a development of these tubercles in one or more organs of the body. The distribution and number of the tubercles determine the course of the disease.

In a large number of cases the changes are limited to the lungs and the serous membranes[a] of the thorax and abdomen. Pathologists

[a] These membranes comprise the smooth, very delicate, glistening lining of the large body cavities. In the thorax the serous membrane (pleura) covers the ribs and diaphragm as well as the whole lung surface. In the abdomen a similar membrane (peritoneum) lines the interior of the cavity and covers the bowels, liver, spleen, etc.

have been in the habit of calling the lung disease tuberculosis and the disease of the serous membranes " pearly disease." Statistics have shown that in about one-half of the cases both lungs and serous membranes are diseased, in one-third only the lungs, and in one-fifth only the serous membranes. At the same time the lymphatic glands near the diseased organs are usually involved. Other organs, such as the liver, not infrequently contain tubercles. Though the disease may remain restricted to a single organ, it now and then is found generalized, affecting all organs of the body.

In the lungs the changes observed vary according to the age and intensity of the disease process. They usually begin with the appearance of very minute tubercles. These may appear in large numbers on the surface of the lungs or within the lung tissue. Later the contents become cheesy and partly calcified. When these tubercles are sufficiently numerous to become confluent, large masses may be formed, which undergo the same retrogressive changes of caseation and calcification. In addition to the formation of tubercles in the lung tissue, certain other changes take place. There is usually present bronchitis, with abundant catarrhal secretion. This plugs up the smaller air tubes, and the lung tissue supplied with air by these tubes collapses. Subsequently it becomes filled with yellowish, cheesy matter, which greatly distends the small air tubes and air vesicles (broncho-pneumonia). The connective tissue between the lung lobules, around the tubercles, and around the air tubes becomes thickened and indurated. In the larynx and the bronchi, tubercles may vegetate upon the mucous membrane, and ulcers may result from their breaking down. The inflammatory irritation which the growth of the tubercules on the surface of the lungs arouses gives rise to adhesion of the lungs to the ribs and diaphragm. This adhesion is sometimes so firm and extensive that the lungs appear grown to the chest wall.

When, therefore, the lungs in advanced stages of the disease are cut open we observe large, yellowish masses, from one-quarter to three-quarters of an inch in diameter, of a cheesy texture in which calcified, gritty particles are embedded and which are surrounded by very firm connective tissue. The neighboring lung tissue, when collapsed and involved in broncho-pneumonia, has the color and consistency of pale-red flesh. The air tubes, large and small, stand out prominently on the cut surface. They are distended with a pasty, yellowish, cheesy mass, surrounded and enveloped in thick mucus, and their walls greatly thickened. The larger bronchi may be sacculated, owing to the distention produced by the cheesy contents.

The disease usually attacks the bronchial glands, which are situated on the trachea and bronchial tubes at the bifurcation. The changes in the glands are the same as those going on in the lung tissue, and they frequently reach an enormous size.

The tubercle formation on the serous membranes covering the lungs and chest wall, which may go on at the same time with the lung disease or independent of it, has been called "pearly disease," on account of the peculiar appearance of the tubercles. These begin as very minute, grayish nodules, which give the originally smooth, lustrous membrane a roughened appearance. These minute tubercles enlarge, become confluent, and project above the surface of the membrane as wart-like masses, attaining the size of pease. In this stage their attachment to the membrane is by means of delicate fibers. The attachment is loose, so that the tubercle hangs by a short pedicle or neck and may be moved slightly to and fro. Large masses are frequently formed by a coalescence of many tubercles and the secondary formation of the same. These may be found on the lungs, the ribs, and the diaphragm. These tubercles likewise undergo degenerative changes; the center partly softens and partly calcifies into a grayish mortar-like mass, and they are gritty. Associated with the formation of tubercles on the pleura, those glands situated back of the center of the lungs between the two main lobes (posterior mediastinal) become greatly enlarged and the center cheesy. They may compress the esophagus and interfere with swallowing. The size attained by these tumors and new growths is well illustrated by the fact that, taken together, they not infrequently weigh from 60 to 80 pounds. The bronchial glands, which in the healthy state are not so large as horse-chestnuts, have been found to attain a weight of over 10 pounds.

In the abdominal cavity tubercles may be found, both in the organs and on the serous membranes covering them. They are situated preferably on the omentum, or caul, the diaphragm, and the walls of the abdomen. In the liver large and small tubercular masses are occasionally encountered. The mesenteric glands are occasionally enlarged and tuberculous; likewise the glands near the liver. Tubercles may also develop in the spleen, the kidneys, the uterus and ovaries, and the testicles.

Tubercular affection of the intestines seems to be quite rare, although ulcers of the large intestines have been observed. Nodules may also form under the serous covering of the intestines.

The brain and spinal cord are occasionally found tuberculous. Of 40 cases, Semmer found tuberculosis of the brain in 4. It is not improbable that, owing to the infrequency of exposing the brain and spinal cord, tuberculosis may have escaped the attention of pathologists, and it may be that it is not so uncommon as is generally supposed. The tubercles occur on the membranes of the brain as well as in the substance of the brain itself. They project into the ventricles as masses, varying in size from a pin's head to a hen's egg. They

finally lead to various inflammatory changes. Jöhne has observed numerous small tubercles on the membranes of the spinal cord.

Very rarely tuberculous lesions have been observed in the bones and muscles of the body. Not so rare, however, is the affection of the lymphatic glands embedded in the muscular tissue and those which can be felt beneath the skin. These are situated at the joints, under the jaw, and along the neck.

Tubercular disease of the udder in cows has received considerable attention of late from sanitarians, owing to the infection of the milk with the virus of tuberculosis. According to those who have given this subject special attention, the udder becomes swollen uniformly and quite firm. This swelling, which is painless, frequently attacks but one quarter, more rarely two, these being usually the hind quarters. The larger milk ducts contain yellowish, cheesy particles, in which are many tubercle bacilli. Later on, larger nodules can be felt within the udder, which undergo the various changes to which tubercles are subject. The udder may grow very hard to the touch and become very large, weighing in some cases up to 40 pounds. The milk, at first normal, becomes thin and watery after a month or so, and is mixed with flakes and tubercle bacilli.

As regards the frequency of the tubercular processes in the different organs, the following carefully compiled statistics of the disease in Bavaria and Baden may serve as a guide:

	Per cent.
Bavaria:	
Tuberculosis of lungs and serous membranes	41
Tuberculosis of lungs alone	33
Tuberculosis of serous membranes alone (pearly disease)	17
Tuberculosis of other organs	8
Baden:	
Tuberculosis of lungs alone	21
Tuberculosis of serous membranes alone	28
Both combined	39
Generalized tuberculosis	9
Tuberculosis of the sexual organs alone	3

Symptoms.—The beginning of the disease usually passes unnoticed, inasmuch as it is very slow and insidious and rarely accompanied by fever. When the lungs are involved a dull, short cough is noticed, which may later on become prolonged, convulsive, and very troublesome to the animal. The cough is more frequent in the morning after movement and drinking. The breathing varies. Only when much of the lung tissue is diseased, it is labored and accompanied by active movements of the chest and nostrils. Discharge from the nose is rare or absent. At times, however, when the tubercles have broken down and cavities containing cheesy masses have formed in the lung tissue, or when the air tubes have become filled with cheesy and mucous masses, coughing will dislodge these and cause their discharge. In

advanced stages the breath may have a disagreeable odor. Pressure on the chest wall may give rise to pain.

The general effect on the body is at first slight. In fact, animals may remain in good flesh for a considerable time. Invariably, as the disease progresses, loss of flesh and appetite and paleness of the mucous membranes become manifest. These are accompanied by a gradual diminution of the milk secretion. The debilitated condition of the animal is also manifested by a staring coat and a tough, dry harsh skin (hidebound). Digestive disturbances are indicated by tympanites, or distention of the rumen by gas, colic, and diarrhea, alternating with constipation. The animal generally dies from exhaustion after a period of sickness which may last months and years.

Tuberculosis in the abdominal organs is often signalized by abortion and by abnormal sexual manifestations. When the brain is involved the disease may cause convulsions, unconsciousness, paralysis, as well as peculiar movements in a circle, oblique position of the head, etc. Lydtin quotes the following description of the disease as taken from a Swiss sanitary order:

A dry, short, interrupted, hoarse cough, which the sick animals manifest especially in the morning at feeding time, still more after somewhat violent exertion. At first these animals may be full-blooded and lay on a considerable amount of fat when well fed. As the disease progresses they grow thin and show more and more those appearances which indicate diseased nutrition, such as a staring, lusterless, disheveled coat; dirty, tense skin, which appears very pale in those regions free from hair. The temperature of the skin is below normal. The loss of fat causes sinking of the eyes in their sockets. They appear swimming in water, and their expression is weak. The cough is more frequent, but never or very rarely accompanied with discharge. The body continues to emaciate even with plenty of food and a good appetite, so that the quantity of milk is small. At times, in the early stages of the disease, still more in the later stages, the diseased animals manifest considerable tenderness when pressure is applied to the front or the sides of the chest, by coughing, moaning, etc. Often all symptoms are wanting in spite of the existence of the disease.

Lydtin also quotes at length a description of the abnormal sexual desire occasionally observed among cows when affected with this disease.

Diagnosis.—A disease so varied in its attack upon the different organs of the body and in the extent of the disease process must necessarily lead to mistakes when diagnosis is attempted by the ordinary means of examination. It has been confounded with the later stages of pleuro-pneumonia, with parasitic diseases of the brain, the lungs, the intestines, and with actinomycosis. A careful examination of the lungs by auscultation and percussion enables the expert to locate large tubercular masses, owing to dullness, loss of respiratory murmur, and abnormal sounds, such as blowing, whistling, and creaking. However, the majority of cases of tuberculosis in cattle,

including many in which the lungs are quite seriously involved, can not be detected in this manner.

The tuberculin test, which is marvelously accurate in its indications, has been almost universally adopted for the detection of tuberculosis. Tuberculin is a drug prepared by sterilizing, filtering, and concentrating the liquids in which the tubercle bacillus has been allowed to vegetate. This substance, discovered by Koch, has the effect, when injected into the tissues of a tubercular animal, of causing a decided rise of temperature, while it has no such effect upon animals free from the disease. The value of tuberculin for this purpose was tested during the years 1890 and 1891 by Guttman, Roeckl and Schütz, Bang and Salomonsen, Lydtin, Jöhne and Siedamgrotzky, Nocard, and many others. It was at once recognized as a most remarkable and accurate method of detecting tuberculosis even in the early stages and when the disease had yet made but little progress.

The tuberculin test came into existence through the most careful and thorough scientific experimentation. In practice it is applied by first taking the temperature of the animal to be tested, at intervals of about two hours, a sufficient number of times to establish the normal temperature of the body under the ordinary conditions of life. The proper dose of tuberculin is then injected under the skin with a hypodermic syringe. The injection is generally made late in the evening, and the temperature is taken every two hours the following day, beginning early in the morning and continuing until late in the evening, if the fullest information is desired. From average temperatures calculated by de Schweinitz in 1896 of about 1,600 tests of tuberculous cows, it appears that in general the rise of temperature begins from five and one-half to six hours after the tuberculin is injected, reaches its greatest height from the sixteenth to the twentieth hours, and then gradually declines, reaching the normal again by the twenty-eighth hour.

A certain number of errors in diagnosis were, however, recorded in these early experiments which raised some question as to whether tuberculin was sufficiently accurate for universal adoption in the examination of cattle for this disease. The failures were of two kinds. A small percentage of the animals which showed an elevation of temperature were apparently free from signs of tuberculosis when examined after slaughter, and about an equal proportion failed to react, which upon slaughter proved to be diseased. Subsequent investigation showed, however, that the supposed errors might be largely reduced, first, by not recognizing any elevation of temperature less than 2° F. as a reaction; second, by requiring that the temperature should go to about 104° F.; third, by taking into account the tuberculin curve of the chart; fourth, by giving a sufficient dose of tuber-

culin; and fifth, by making a more careful search through the carcass after slaughter for signs of the disease. The diseased animals which failed to react were found to be either in an advanced stage of the disease (and this was easily recognizable by other means), or the disease had become arrested and for the time being did not affect the system of the animal.

In 1898, Bang, of Copenhagen, one of the highest European authorities, in his paper presented to the Congress for the Study of Human and Animal Tuberculosis, at Paris, said:

Numerous tests made in almost every civilized country have demonstrated that in the majority of cases tuberculin is an excellent means for diagnosing the existence or the nonexistence of the disease, but giving us no positive information as to the extent to which the disease has progressed. When tuberculin produces a typical reaction we may be almost sure that there exists in the body of the animal a tubercular process. The cases in which a careful examiner has not succeeded in finding it are very rare; and I am led to believe that when, notwithstanding all the pains taken, it has escaped discovery, the reason is that it is located in a portion of the body that is particularly inaccessible. Nevertheless, it is not to be denied that a fever, entirely accidental and of short duration, may in some rare cases have simulated a reaction. However this may be, the error committed in wrongly condemning an occasional animal for tuberculosis is of no practical consequence.

A worse aspect of the case is that there are some diseased animals in which tuberculin fails to discover the existence of tuberculosis. In most of these, no doubt, the deposits are old, insignificant, and generally calcified, or they are cases where the disease is arrested and perhaps in process of recovery, and which are possibly incapable of disseminating the contagion. But it is known that there are cases, not altogether rare, where tuberculin fails to cause a reaction in a highly tuberculous animal, and consequently one in which the disease exists in an extremely contagious form. For this reason a clinical examination should always be made of an animal which does not give a reaction, but which shows symptoms indicating that notwithstanding the test it may suffer from tuberculosis.

Nocard, of Paris, wrote also in 1898 as follows:

The degree of certainty of the indications furnished may be stated in precise terms. *The observation of a clear reaction to tuberculin is unequivocal; the animal is tuberculous.* The pretended errors imputed to the method are explained by the extreme sensitiveness of the reagent, which is capable of detecting the smallest lesion. It often requires prolonged and minute researches in the depths of all the tissues to discover the few miliary centers, the presence of which has been revealed. The reaction is absolutely specific. In those cases where it is observed, with animals which show lesions of another disease (actinomycosis, hydatid disease, verminous bronchitis, distomatosis), it may be affirmed that there exists, in addition to these conspicuous changes, a tuberculous center which alone has provoked the reaction.

The failure to react does not necessarily imply absence of tuberculosis. Such failures of tuberculin are very exceptional. They are seen most frequently with animals affected with tuberculosis in a very advanced stage and made evident by plain external signs. Sometimes, also, there are found at the postmortem examination of animals which have not reacted small fibrous or calcified

lesions in such a condition that one is tempted to believe them cured. Whether sterile or not, these lesions have no tendency to increase and they are not very dangerous from the point of view of contagion.

These opinions of two eminent authorities, living in different countries, after long experience of their own and after studying the results of the many tests made in different parts of the world, should have great weight; they are essentially the same throughout. A similar conclusion was reached from experiments made in the Bureau of Animal Industry in 1893. In the extensively diseased herd of the Washington Soldiers' Home, 60 animals were tested, all of which were afterwards slaughtered and carefully examined. Of the 60 animals tested, 49 reacted and 11 failed to react. Tuberculous lesions were found in 48 of the animals which reacted. Five animals which did not react were also found to be diseased. One of these had a high temperature (103.6° F.) the day before the test, and this animal had extensive tuberculosis. The disease had been recognized in this animal from external appearance, and it had been isolated from the herd from fifteen to eighteen months. Three other animals which did not react were in all probability stationary cases of disease; the nodules were small and largely calcareous. In the remaining animal which failed to react the lesions were also small and apparently confined to the glands.

In 1897 Voges compiled statistics of tuberculin tests, the accuracy of which had been determined by postmortem examination. Of 7,327 animals tested, it appeared that errors had been made with 204, or 2.78 per cent. In the work of the Pennsylvania Live Stock Sanitary Board, postmortem examinations were made on about 4,400 reacting cattle, and the disease was found in all but 8 of those which had given characteristic reactions.

The results of a much larger number of tests might be compiled at this time, but they would not materially change the average of those already mentioned. It is plain that tuberculin is a remarkably accurate test of tuberculosis; that the animals which react may be safely considered as tuberculous, and that when a careful clinical examination is practiced in addition to the test, there are few animals in a dangerous condition which escape detection.

The first questions asked by those who oppose the adoption of the tuberculin test are, Is this test infallible? and, If it is not infallible, why should it be forced upon the cattle owners of the country?

In answer to these questions it may be said that tuberculin is not absolutely infallible, and yet it is by far the best method of diagnosing tuberculosis that has been discovered. It is much better than any test known for pleuro-pneumonia when that disease was eradicated.

Practically all the animals which react are affected with tuberculosis and should be separated from the herd, not only in the interest of the public, but in the interest of the owner of the herd. The best authorities admit, after studying many thousands of tests, that there are few if any mistakes made in condemning cattle which show a typical tuberculin reaction. The errors are principally in the other direction—that is, some tuberculous animals are not discovered by the tuberculin test; but as the most dangerous of these may be picked out by ordinary clinical examination, this fault of tuberculin is not so serious as it at first sight appears. This being the case, it should not be necessary to force the tuberculin test upon cattle owners. They should be anxious to adopt it in their own interests and for the protection of their patrons. There is to-day no greater danger to the cattle and hog industries than that which confronts them in the form of tuberculosis, a disease already widespread and rapidly extending. Without the use of tuberculin it would be impossible to control this disease, and the farmer and stock raiser would be at its mercy. With tuberculin its control is not a difficult matter, and badly affected herds may be converted into healthy herds in a few years, and without very serious loss or hardship. Tuberculin is, therefore, a great boon to the farmer—one of the most beneficial scientific discoveries of modern times.

Some cattle owners have been prejudiced against the tuberculin test by incorrect or greatly exaggerated statements as to damage caused to cattle by the injection of tuberculin. Some of these statements have been based upon attacks of illness in no way connected with the tuberculin test.

Many persons have in recent years studied the effects of tuberculin as they have been revealed by tests covering vast numbers of animals, and in the present uncertain condition of the public mind in this country on the subject the writer deems it advisable to quote the conclusions of some of the best authorities.

Nocard and Leclainche say:

> Direct experiments and observations collected by thousands show that the tuberculin injections have no unfavorable effect. With healthy animals the system is indifferent to the inoculation; with tuberculous animals it causes only slight changes, which are not at all serious.

Bang has written as follows on this question:

> We will now consider the following question, a very important one, in the application of tuberculin, viz: Can the reaction produce a worse condition in tuberculous animals than before existed? Hess emphatically states that it can, and on this account he earnestly warns against its application. My attention has been directed to this question from the beginning. In my first publication on tuberculin injection I reported two cases in which acute miliary tuberculosis was proved in two high-grade tuberculous cows several weeks after the tuberculin injection. I then stated my suspicion that perhaps the tuberculin injec-

tion had some connection with this, just as is often supposed to be the case in human practice. With my present very large amount of material for observation at hand I may express the following opinion: Such an acute development of tuberculosis as a result of tuberculin injection is to be feared only exceptionally, and then in cases of advanced tuberculosis. *It must not be forgotten that acute miliary tuberculosis by no means rarely accompanies an advanced tuberculosis of long standing.* It is therefore impossible to offer strict proof of the causal connection with the injection, and only oft-repeated observation could make this probable. In support of my view I offer the following: In the course of the last three years I have made careful postmortem examinations of 83 tuberculous animals, which have been removed from my experiment farm, Thurebylille. Among these were 18 (or, strictly speaking, 23) high-grade tuberculous animals. I have been able to prove miliary tuberculosis in only 4 of these. Among the others, which showed less developed tuberculosis, I have never found miliary tuberculosis, and with very many I have never found any sign of a more rapid development of the process. On the contrary, it has been proved that the disease was restricted locally, often for years, in spite of yearly repeated injections. Dissections were made at very different periods after the injections—in 17 cases from four to twelve days after the last test. In all of these cases earlier tests had been made months or years before. In 28 cases the injection took place from nineteen days to two months before the butchering; in 3 of these cases earlier injections had been made. In 38 cases from two and one-half months to one year intervened between the last injection and the dissection. Dissection gives the best explanation of this question, but a clinical observation, continued for years, of a herd tested with tuberculin can render very essential aid. If Hess's opinion is correct, it is to be assumed that tuberculosis must take an unusually vicious course in such herds, but this I have been unable to prove. At Thurebylille there has existed for three years a reacting division, consisting originally of 131 head and now of 69. Although these animals are yearly tested, and although most of them react every year, the division certainly appears to be made up of healthy animals, and the farm inspector has expressed the decided opinion that the tuberculosis in this division is no more developed than at the beginning of the experiment. The testimony of many owners of large herds of cattle which have long ago been injected is to the same effect. I will adduce statements from several. A farm tenant whose cattle were injected twenty months previously, when 82 per cent of the grown animals reacted, wrote me recently as follows: "Only 2 cows from the division of 100 head had been sold as decidedly tuberculous. The majority appeared afterwards, just as before, entirely healthy. The fat animals which had been slaughtered had been pronounced healthy by the butchers." Another farm tenant with a herd injected in 1894 had not been obliged to remove a single animal from the tuberculous division, numbering 70 head. A large farm owner in Jutland stated in September that he had traced no undesirable result from the injection. His herd of 350 had been injected in February and about 75 per cent reacted. Similar answers have been given by other owners and veterinarians.

A veterinarian who had injected 600 animals, among them a herd of a large farm, eighteen months previously, expressed the belief that the injection had produced in no single case an unusually rapid or vicious course of tuberculosis. In spite of a demand made months ago, I have received thus far no report from any veterinarian of an undesirable result.

On a large farm, on which before the injection tuberculosis had appeared in a vicious form, the owner had the impression that the severe cases had afterwards become more numerous. He had, however, not suffered severe losses, and eight months later the large reacting division by no means made a bad

impression. Finally, it is to be noticed that tuberculin has been employed on a large scale in Denmark for years, and still the demand from farmers constantly increases. This could certainly not be the case if the injections were generally followed by bad results.

Paige said, after the tests of the herd of the Massachusetts Agricultural College, that "its use is not followed by any ill effects of a serious or permanent nature."

Lamson, of the New Hampshire College Agricultural Experiment Station, said: "There is abundant testimony that its use is not in any way injurious to a healthy animal."

Conn, who made a special study of the present attitude of European science toward tuberculosis in cattle, reached the following conclusions:

It has been, from the first, thought by some that the use of tuberculin produces a direct injury upon the inoculated animals. This, however, is undoubtedly a mistake, and there is no longer any belief anywhere on the part of scientists that the injury thus produced is worthy of note. In the first place, the idea that it may produce the disease in a perfectly healthy animal by the inoculation is absolutely fallacious. The tuberculin does not contain the tubercle bacillus, and it is absolutely certain that it is impossible to produce a case of tuberculosis in an animal unless the tubercle bacilli are present. The use of tuberculin, therefore, certainly can never produce the disease in the inoculated animal.

It has been more widely believed, however, that the inoculation of an animal with this material has a tendency to stimulate an incipient case of tuberculosis. It has been thought that an animal with a very slight case of the disease may, after inoculation, show a very rapid extension of this disease and be speedily brought to a condition where it is beyond any use. The reasons given for this have been the apparent activity of the tuberculosis infection in animals that have been slaughtered shortly after inoculation. This has been claimed, not only by agriculturists who have not understood the subject well, but also by veterinarians and bacteriologists. But here, too, we must recognize that the claim has been disproved, and that there is now a practical unanimity of opinion, on the part of all who are best calculated to judge, that such an injurious effect does not occur. Even those who have been most pronounced in the claim that there is injury thus resulting from tuberculin have, little by little, modified their claim, until at the present time they say either that the injury which they formerly claimed does not occur, or that the stimulus of the disease is so slight that it should be absolutely neglected, in view of the great value which may arise from the use of tuberculin. Apart from two or three who hold this very moderate opinion, all bacteriologists and veterinarians unite in agreeing that there is no evidence for believing that any injury results. In Denmark, especially, many hundreds of thousands of animals have been inoculated, and the veterinarians say there is absolutely no reason in all their experience for believing that the tuberculin inoculation is followed by any injurious results.

In 1898 tuberculosis was found in the large Shorthorn herd belonging to W. C. Edwards, of Canada, who with commendable promptness and public spirit had his animals tested, and at once proceeded

to separate the diseased from the healthy animals. These were all finely bred animals, and the very class which we have been told are most susceptible to the injurious effects of tuberculin. After using this test regularly for two years, Mr. Edwards wrote as follows:

> I have seen nothing to lead me to believe that the tuberculin test had any injurious influence on the course of the disease. It is by no means our opinion that the disease has been stimulated or aggravated by the application of the tuberculin test. All animals that we have tested two or three times continue as hale and hearty as they were previously, and not one animal in our herds has broken down or failed in any way since we began testing.

Mr. Edwards, in December, 1901, verbally stated to the writer that his views as to the harmlessness of tuberculin remained unchanged, and that he had not seen the least ill effect with any of his cattle from its use.

Those who have had most experience with tuberculin have failed to observe any injurious effects following its use upon healthy cattle. With tuberculous cattle it produces a fever of short duration, and in the great majority of cases all derangement of the system which it causes disappears within forty-eight hours after the tuberculin is administered. There appear to have been a very few cases in which the disease was aggravated, and a greater number in which it was benefited by the injection of tuberculin. The cases of abortion following the tuberculin test have not been numerous, even when cows were tested within a few weeks of the normal time of calving. The few cases of abortion which have occurred may be explained by the fact that abortion in cattle is a very common occurrence, and that it would inevitably happen sometimes after the tuberculin test as a mere coincidence, and without any relation between the test and the loss of the calf. The cases of abortion which have been cited appear to be no more numerous than might be expected to have occurred among the same number of cattle within the same period if the test had not been applied.

From the investigations and observations that have been mentioned, it may be safely concluded—

(1) That the tuberculin test is a wonderfully accurate method of determining whether an animal is affected with tuberculosis.

(2) That by the use of tuberculin the animals diseased with tuberculosis may be detected and removed from the herd, thereby eradicating the disease.

(3) That tuberculin has no injurious effect upon healthy cattle.

(4) That the comparatively small number of cattle which have aborted, suffered in health, or fallen off in condition after the tuberculin test, were either diseased before the test was made or were affected by some cause other than the tuberculin.

Tuberculin is not always concentrated to the same degree, and therefore the dose varies. The dose of the imported tuberculin is 0.25 c. c. for an adult cow, and, before injection, is diluted with sterile water to 2 c. c. The tuberculin made by the Bureau of Animal Industry is prepared so that it will not be necessary to dilute it, and the dose is 2 c. c.

Treatment of the disease is not seriously considered by any authorities at the present time.

The measures to be adopted to prevent the spreading of the disease must take into consideration not only the tubercle bacillus, but likewise all those circumstances which make cattle more susceptible to the disease which have already been dwelt upon. It would be useless to repeat here all that has been said above on the transmission of tubercle bacilli from one animal to another, and on the dangers of certain debilitating influences. A careful study of these will show how tuberculosis may, at least in some cases, be prevented. Great care should be bestowed upon the breeding, the surroundings, and the food of the animal, so that the latter may be put into a condition to resist infection even when exposed to it. A tuberculin test should be applied to all strange cattle before they are introduced into the herd, and those which show a reaction should be refused.

A rigid exclusion of tuberculous animals is all that is necessary to prevent the appearance of the disease, provided cattle are not infected by consumptive persons and animals, which we can not consider as impossible at the present time, though it is probably unusual, because the bacilli from man are in the majority of cases attenuated and harmless for cattle.

Tuberculosis in cattle must also be considered as bearing upon tuberculosis of other domesticated animals, particularly hogs. In Europe and the United States this disease is not so uncommon among hogs and appears to be on the increase. The reason for its existence may be looked for in the feeding of pigs with skim milk, buttermilk, and whey in dairies, with the offal of the abattoirs, and the household refuse generally. If tuberculosis is common among cattle, it is likely to be transmitted to hogs kept in this way.

The carcasses of animals which have died of tuberculosis should be buried deeply, so that they can not be eaten by other animals. This is likewise true of all organs or tissues of slaughtered animals containing tubercles. These should never be fed to other animals, such as hogs, dogs, and cats, and should either be destroyed by fire or deeply buried.

When any of the animals in a herd of cattle show evident symptoms of tuberculosis, or when they are proved to be affected with this disease by the tuberculin test, the best method of procedure in most cases is to have the affected animals slaughtered and the stables dis-

infected. A large proportion of the animals which are slightly affected yield carcasses which are perfectly wholesome and fit for human food, but in all such cases there should be an inspection by an expert at the time of slaughter to determine which carcasses may be used and which should be destroyed.

The disinfection of stables may be accomplished by thoroughly cleaning them, scrubbing the floors with hot water, brushing down all loose dust from the walls, and tearing off all woodwork which is partly decayed. Then the whole interior of the stable should be covered with a good coat of lime wash containing 1 part of formalin (which is a 40 per cent watery solution of formaldehyde) to 30 parts of the lime wash, or 4 ounces of formalin to each gallon of lime wash.

If all of the animals which react are destroyed and the stables disinfected in this manner, the herd should remain free from the disease unless other affected animals are added to it. The introduction of the disease in this manner may be avoided by requiring a tuberculin test of all new animals admitted on the premises.

It is unfortunately a fact that animals with tuberculosis which have been tested several times may become so accustomed to tuberculin that they will no longer react; consequently it is always advisable to purchase cattle from some one who is known to be reliable, as otherwise tubercular animals may be treated with tuberculin for the purpose of hiding the disease.

In the case of very valuable thoroughbred animals it may be more advantageous to retain the reacting animals which are in good condition, in order to breed from them, and in that manner avoid the excessive loss which would follow from their immediate slaughter. This may be done safely if proper precautions are adopted. The healthy animals should be separated from the diseased ones, and the stable in which the diseased animals have been should be frequently disinfected. When calves are dropped by the tubercular cows they should be immediately removed, or at least not allowed to drink the mother's milk more than once or twice, and after that fed upon the milk of healthy cows. The milk from the animals which have reacted should not be used until after it has been boiled and the tubercle bacilli thus destroyed. The young animals which are raised from tubercular dams should be tested when they are about six months old, and all of those which react should be immediately slaughtered. It has been found that by following the plan suggested above not more than 1 or 2 per cent of the calves will develop tuberculosis. It is, of course, some trouble to follow this method, but it enables the owner of a purebred herd to retain the strains of blood which he has been breeding, and gradually to eliminate the disease. At the end of six or eight years he should have a herd of cattle free from tuberculosis and be prepared to destroy all of those which have reacted.

Bovine tuberculosis and the public health.—The identity between human and animal tuberculosis, combined with the extraordinary mortality of human beings from this disease, often amounting to 10 to 14 per cent, has raised the question in all civilized countries as to how far animal, and especially bovine, tuberculosis was to blame for this high mortality. The medical and veterinary professions have approached this problem with equal zeal, and much has come to light within recent years which enables us to come to some conclusion. If this disease is transmitted from animals to man, how does the transmission take place? As comparatively few people come in direct contact with tuberculous cattle, it must be either through the meat, the milk, the butter, the cheese, or through all of these products that the virus enters the human body. The question has thus narrowed itself down to the food products furnished by cattle.

It has become a very urgent question, especially in the poorer countries of Europe, whether all flesh from tuberculous animals is unfit for human food. It is argued there that if it can be shown that in the majority of cases of tuberculosis the bones and the muscular system are free from infection, there is no reason why the meat should not be put on sale under certain restrictions. The question may be resolved into two divisions: (1) How frequently does the disease invade those parts of the body which are used as food? (2) When the disease process is manifestly restricted to the internal organs do tubercle baccilli circulate in the blood and lymph, and can they be detected in the muscular tissue?

(1) Disease of the bones is not unknown, although very rare. According to Walley, it appears chiefly in the spongy bones of the head and backbone and in the long bones of the limbs. Occasionally the ends of the bones, where they are covered by the synovial membrane of the joints, are dotted with tubercles. The muscular system itself is very rarely the seat of tubercular deposits, although the lymphatic glands lying near and among the muscles may be not infrequently diseased.

(2) Whether tubercle bacilli are found in muscle juice independent of any tubercular deposits is a question which must be approached experimentally There is on record a great variety of opinions on this matter, some authorities considering all flesh from tuberculous animals unfit for food, while others hold a contrary view. Experiments have shown that in rare cases the flesh of tuberculous cattle contains a small number of tubercle bacilli. In Germany the flesh of animals in which the disease is just beginning, or in which it is restricted to one or more related organs, is not rejected. When, however, the disease has affected the muscles, or bones, or lymphatic glands situated on or between them, the flesh is condemned as unfit and dangerous. Animals are also rejected in which it is evident,

from the general distribution of tubercles throughout the various organs, that the bacilli have been distributed by the blood and may have been carried into the muscular system (generalized tuberculosis).

Concerning the infectious nature of milk secreted by tuberculous cows, authorities have universally agreed that when the udder itself is in the slightest degree involved the milk possesses infectious properties, and is therefore dangerous. Tubercle bacilli have been found in large numbers in the milk and the udder under such circumstances. Unlike other affections of the udder, tuberculosis of this organ does not at once change the appearance and the quality of the milk secreted. Bang states that for at least a month after the disease has appeared the milk is normal in appearance and may be consumed and sold without arousing the suspicion of the owner. There is, therefore, considerable danger involved in this disease, and the necessity for the careful inspection of dairy cows seems more urgent than ever before.

Authorities are, however, not fully agreed as to whether the milk from tuberculous cows in which the udder is apparently not invaded by the disease should be considered dangerous or not. Some are inclined to believe that the milk secreted by healthy udders is never infectious, even when the lungs or other organs are affected; that, in other words, the tubercle bacilli are rarely, if ever, separated from the lesions which they produce, and that the udder itself must be diseased before tubercle bacilli can appear in the milk. Experiments made with the milk of tuberculous cows in which there were no indications of udder disease do not bear out this theory, since tubercle bacilli have been found in the milk of such cows. Some authorities still believe that the udder is diseased when the milk is infected, but that the disease escapes observation. However this may be, the fact that the udder may be diseased and the disease not recognizable simply casts suspicion upon all milk from tuberculous animals. We know that the milk of tuberculous cattle may or may not contain tubercle bacilli when the udder is apparently free from disease. But we have no rapid method of determining whether, in any given case, the milk contains tubercle bacilli or not. Moreover, the bacilli may be absent at one time and present at another in milk from the same cow. When we consider, therefore, the extent of tuberculosis and the hidden character of the disease, a certain amount of suspicion rests upon all milk. Fortunately tubercle bacilli are readily destroyed by the temperature of boiling water, and hence both meat and milk are made entirely safe, the former by the various processes of cooking, the latter by boiling for a few moments. Until better means of diagnosis are at hand, it is incumbent upon all communities to have dairy cows examined or inspected, at least to the

extent of finding out whether the udder shows any signs of disease. If this is detected, the affected animal should be killed at once, or else all opportunity for the sale of such milk removed by appropriate measures. The dangers from infected milk might by these means be very materially lessened.

Recently there has been much discussion of the question as to whether human and animal tuberculosis are identical diseases and as to the possibility of the tuberculosis of animals being transmitted to man, or that of man being transmitted to animals.

The fact that tubercular material from human subjects often failed to produce serious disease in cattle was observed by a number of the earlier investigators who experimented with such virus. It was the experiments and comparative studies of Theobald Smith, however, which attracted special attention to the difference in virulence shown by tubercle bacilli from human and bovine sources when inoculated upon cattle. Smith mentioned also certain morphological and cultural differences in bacilli from these two sources, and in the location and histology of the lesions in cattle produced by such bacilli. He did not conclude, however, that bovine bacilli could not produce disease in the human subject, but said:

> It seems to me that, accepting the clinical evidence on hand, bovine tuberculosis may be transmitted to children when the body is overpowered by large numbers of bacilli, as in udder tuberculosis, or when certain unknown favorable conditions exist.

Koch, however, in his address at the British Congress on Tuberculosis, went far beyond this and maintained that "human tuberculosis differs from bovine and can not be transmitted to cattle." As to the susceptibility of man to bovine tuberculosis, he said it was not yet absolutely decided, but one was "nevertheless already at liberty to say that, if such a susceptibility really exists, the infection of human beings is but a very rare occurrence." He emphasized this view in the following language:

> I should estimate the extent of infection by the milk and flesh of tubercular cattle and the butter made of their milk as hardly greater than that of hereditary transmission, and I therefore do not deem it advisable to take any measures against it.

This conclusion was so radically different from the views of most experimenters and so out of harmony with facts which had apparently been demonstrated by others that it at once aroused opposition in the congress, followed by the adoption of dissenting resolutions, and led to numerous investigations in various countries. Koch's conclusions were based upon his failure to produce tuberculosis in cattle and other animals by inoculating them with tubercular material of human origin, and his success in causing progressive and fatal tuberculosis in

the same kinds of animals when inoculated with tubercular material of bovine origin. With such positiveness did he hold to the constant and specific difference between the human and bovine bacillus that he promulgated an experimental method of discriminating between them. Speaking of the etiology of intestinal tuberculosis in man, he said:

> Hitherto nobody could decide with certainty in such a case whether the tuberculosis of the intestine was of human or of animal origin. Now we can diagnose them. All that is necessary is to cultivate in pure culture the tubercle bacilli found in the tubercular material, and to ascertain whether they belong to bovine tuberculosis by inoculating cattle with them. For this purpose I recommend subcutaneous injection, which yields quite specially characteristic and convincing results.

These important and comprehensive conclusions followed from a comparatively few experiments upon animals, and apparently no effort had been made to learn to what extent human tubercle bacilli might differ in their virulence for cattle or what grades of virulence there might be among bacilli of bovine origin. Vagedes had already shown that bacilli were sometimes present in human lesions which were as virulent as bovine bacilli, but his work was wholly ignored by Koch.

A considerable number of investigators, including Chauveau, Vagedes, Ravenel, De Schweinitz, Mohler, De Jong, Delépine, Orth, Stenström, Fibiger and Jensen, Max Wolff, Nocard, Arloing, Behring, Dean and Todd, Hamilton and Young, the German Tuberculosis Commission, and Theobald Smith, have found tubercle bacilli in the bodies of human beings that died of tuberculosis which proved to have about the same virulence for cattle as had the bacilli from bovine animals affected by the disease.

Kossel, in a preliminary report, stated that the German commission had tested 7 cultures of tuberculosis from cattle and hogs—4 from cattle and 3 from hogs. Two of these cultures proved acutely fatal in cattle after eight to nine weeks; 4 of the cultures likewise produced a generalized tuberculosis, but which certainly had a more chronic course; while 1 of the cultures caused only an infiltration at the point of inoculation, with some caseous foci in the adjoining prescapular gland and in one of the mediastinal glands, and there was lacking the spreading of the tuberculosis over the entire body which they were accustomed to see after the injection of cultures of bovine tuberculosis. "Hence," says Kossel, "among bovine tuberculosis bacilli there can also occur differences with regard to the virulence."

The German commission also tested 39 different freshly made cultures from tuberculous disease in man. Nineteen of these cultures did not produce the slightest symptoms in cattle; with 9 others the cattle exhibited after four months very minute foci in the prescapular

glands, which were mostly encapsuled and showed no inclination to progress; with 7 other cases there was somewhat more marked disease of the prescapular glands, but it did not go so far as a material spreading of the process to the glands next adjoining. There were 4 cultures, however, which were more virulent and caused generalized tuberculosis in the cattle inoculated with them.

It would appear, therefore, that hereafter everyone must admit that it is impossible always to tell the source of a culture of the tubercle bacillus by its effects when it is inoculated upon cattle. One of the bovine cultures failed to produce generalized tuberculosis in cattle, and some of the human cultures did produce this form of the disease in such animals. Moreover, while some of the human cultures caused no disease at all, others led to the development of minute foci in the prescapular glands, and still others to somewhat more marked disease of these glands. There were, consequently, four degrees of virulence noted in these 39 cultures of bacilli from human sources and three degrees of virulence in the 7 cultures from animal sources.

Now, if we accept the views of Koch as to the specific difference between human and bovine tubercle bacilli, and that the human bacilli produce only localized lesions in cattle, while bovine bacilli produce generalized lesions in these animals, must we not conclude that the one nonvirulent bovine culture was in reality of human origin, and that the animal from which it was obtained had been infected from man? This is a logical deduction, but reverses the dictum laid down at London that human tuberculosis is not transmissible to cattle. Again, how are we to explain the human cultures of medium virulence? Are they human bacilli which, for some unknown reason, are increasing in virulence and approaching the activity of the bovine bacillus? Or are they really bovine bacilli which have multiplied in the human body until their virulence has become attenuated? In whatever manner these questions are decided it would seem that the findings of the German commission, instead of supporting Koch's views that we can decide with certainty by the inoculation of cattle as to the source of any given bacillus, really show that this method of diagnosis is extremely uncertain in the present condition of our knowledge.

It is definitely admitted that 4 of the human cultures caused generalized tuberculosis in cattle; but Kossel suggests that it might be possible that the bacilli in cases of human tuberculosis under certain circumstances could likewise attain a very high pathogenic activity for cattle without being for that reason bovine bacilli. Undoubtedly the German commission is confronting the two horns of a dilemma, either one of which is fatal to the views of Koch as stated with such positiveness at London. If we accept this suggestion thrown out by Kossel, we must conclude that Koch was wrong in his claim that human tuberculosis can not be transmitted to cattle, and thus with

one blow we destroy the entire experimental support which he had for his argument before the British Congress on Tuberculosis. And if, on the other hand, we accept the conclusion which follows from the principle laid down by Koch for the discrimination between human and bovine bacilli, and which appears to be favored by Kossel, we must admit that bovine tuberculosis is an extremely important factor in the etiology of human tuberculosis. Of the 39 cases of human tuberculosis tested, 4, or over 10 per cent, were virulent for cattle and would be classified as of bovine origin, but these 4 cases were all found among the 16 cases of tuberculosis in children which the commission investigated; hence it is plain that 25 per cent of the cases tested of tuberculosis in children would by Koch's method be classified as of bovine origin.

In the Bureau of Animal Industry two distinct lines of experiments have been carried on, in order that one might serve as a check against the other. There has been, however, no discrepancy in the results. De Schweinitz, in the Biochemic Division, Bureau of Animal Industry, has isolated 9 cultures from human tuberculosis. Two of these were derived from human sputum, 3 from cases of generalized tuberculosis in adults, and 4 from cases of generalized tuberculosis in children. By comparing these cultures with a newly isolated virulent culture of bovine tuberculosis, there were found among them 2 cultures from children which were identical in their cultural and morphological characters with the bovine bacillus. These cultures also killed rabbits and guinea pigs in as short a time as did the bovine bacillus. Hogs which were inoculated subcutaneously with these two cultures from children died of generalized tuberculosis. Two calves weighing over 300 pounds each were inoculated subcutaneously with these virulent human cultures, and as a result developed generalized tuberculosis. A yearling heifer inoculated with one of the cultures showed generalized tuberculosis when killed three months after inoculation. Both the cattle and the hogs had been tested with tuberculin and found to be free from tuberculosis before the inoculations were made. It is important to observe in this connection that two out of four, or 50 per cent, of the cultures obtained from cases of generalized tuberculosis in children proved virulent for cattle.

Mohler, working in the Pathological Division, Bureau of Animal Industry, has obtained three very virulent cultures of tubercle bacilli from the human subject. A goat inoculated subcutaneously with one of these cultures died in thirty-seven days with miliary tuberculosis of the lungs involving the axillary and prescapular glands. This bacillus was obtained from the mesenteric gland of a boy. Of still greater interest is a bacillus isolated by Mohler from human sputum. A goat inoculated subcutaneously with a culture of this germ died in ninety-five days of pulmonary tuberculosis. A cat inoculated in the same

manner died in twenty-three days of generalized tuberculosis. A rabbit similarly inoculated died in fifty-nine days of pulmonary tuberculosis. Another rabbit inoculated with a bovine culture for comparison lived ten days longer than the one inoculated with this sputum germ. Mohler also inoculated subcutaneously a 1-year-old heifer with a culture derived from the tubercular mesenteric gland of a boy 4 years of age. This culture was always refractory in its growth under artificial conditions, and the bacilli were short, stubby rods, corresponding in appearance with the bovine type. At the autopsy, held one hundred and twenty-seven days after the inoculation, the general condition was seen to be poor and unthrifty, and large, hard tumors were found at the points of inoculation. On the right side the swelling measured $3\frac{1}{2}$ by 5 inches, and the corresponding lymph gland was $2\frac{3}{4}$ inches long by $1\frac{3}{4}$ inches in diameter. This gland contained numerous calcareous foci; one of these at the apex was an inch in diameter. The lesions on the left shoulder of the animal were very similar to those found on the right side, but the dimensions of the tumor were slightly less. The lungs presented an irregular mass of tubercular nodules, and seven or eight grape-like nodules were seen on the parietal pleura. Bronchial and mediastinal lymph glands contained numerous tubercular foci, and the pericardium, peritoneum, spleen, and liver were also affected.

In order to throw some light, if possible, upon the morphological constancy of the different types of tubercle bacilli, Mohler has made comparative studies of bacilli from various sources, and which had been passed through various species of animals, by making the cultures upon dog serum after the method described by Theobald Smith. Some important results have been obtained. One culture of human bacilli which had morphological and cultural peculiarities similar to those of the bovine bacillus, and which only produced local lesions in cattle, was passed through a series of five cats. It was then found to be completely changed in its morphological characters, the rods being elongated, slender, more or less beaded, and entirely of the human type. But far from decreasing in virulence, as might be expected from its morphological appearance, this bacillus had so increased in its pathogenic activity that it now produced generalized tuberculosis in a cow. This cow was inoculated subcutaneously in front of each shoulder with 2 c. c. of a salt solution emulsion of the tuberculous omentum of the last cat of the series. The cow rapidly lost flesh, had a temperature of 104° F., with the point of inoculation and adjacent glands greatly swollen. The autopsy revealed generalized tuberculosis, involving the lungs, mediastinal glands, spleen, liver, and kidneys. Tubercle bacilli of the bovine type obtained from the mesenteric glands of a sheep, hog, and cow were similarly transformed in their morphological appearance after being passed through

a series of cats and recovered on dog serum. These bacilli also increased in virulence, as the last cat in the series invariably succumbed in a shorter time than the first of the series.

These experiments and observations indicate that the types of tubercle bacilli are very inconstant, and that under suitable conditions they readily change both in morphology and in virulence. A similar conclusion was reached by other investigators in working with the avian and piscine types of tubercle bacilli several years ago, and was reasonably to have been expected with the human and bovine types.

It must be plain to all, from these recent developments, that too much has been made of the slight differences in cultural characteristics, in morphology, and in virulence which have been observed in some cases in comparing the human and the bovine bacilli. The observations were interesting, and it was important that they should be followed up until their significance was made entirely clear; but it was an almost unpardonable error, from a sanitary point of view, to promulgate sweeping generalizations calculated to arrest and abolish important measures for preventing human tuberculosis before the soundness of these generalizations had been established by a thorough course of experimentation.

When Koch said in the British Congress on Tuberculosis that he should estimate the extent of infection by the milk and flesh of tubercular cattle and the butter made of their milk as hardly greater than that of hereditary transmission, and that he therefore did not deem it advisable to take any measures against it, he went far beyond what was justified by any experiments or observations which he reported, and he did an immense amount of harm, which will be manifested for years to come to those who endeavor to guard the human race from the dangers of animal tuberculosis. The researches which have been alluded to make these dangers more definite and certain than they have appeared before, and sanitarians should therefore most earnestly endeavor to counteract the erroneous and harmful impression which was made by Koch's address at London and his subsequent address at the International Conference on Tuberculosis at Berlin.

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